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A Primer on Acquisition Logistics

by

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In late 1975, the Navy was about to proceed with contracts for full development for the F/A-18 Hornet fighter. Reports from the fleet showed that existing aircraft required repairs after only 30 to 45 minutes in the air. The planes were superb—when everything was working. However, they were not working long enough to get the job done. At this point, the Navy Material Command brought in Willis Willoughby.

During the Apollo space program, Willoughby had been responsible for making sure that the spacecraft worked perfectly all the way to the moon and back. In coming to the Navy, he was appalled by what he saw. He knew that the Navy could not afford unreliable aircraft, so he insisted that contracts for the F/A-18 contain specifications for reliability and maintainability instead of just flight performance.

Willoughby's efforts were successful. The F/A-18, with some revolutionary new performance capabilities, entered the fleet with greater reliability than more mature systems and required less than half as many man-hours of maintenance. In the first operational deployment of the F/A-18 in 1985, a day of flying would end with F/A-18s still ready to fly while the F-14s and A-6s were in for repairs. This success came about because the Navy focused on sustainable design far earlier in the acquisition process than it had before.

The F/A-18 acquisition team had two design goals: to create an engine that could be changed with little logistics difficulty, and to create an engine that could be changed in 20 minutes. The result was an engine that attached to the fuselage at only three points. One engine could be lowered through a hatch on the bottom of the fuselage and another inserted in less than 17 minutes. Contrast this with a Vietnam-era Navy aircraft, the A-4 Skyhawk, where the first step for replacing an engine was to remove the airplane's tail.

Acquisition logistics is the multifunctional, technical management discipline associated with designing and developing systems like the F/A-18. However, acquisition logistics might not be the discipline it is today without the people and tools used to develop complex and expensive weapon systems. Every discipline evolves in time; yet the evolution of acquisition logistics in recent years remains elusive to many practicing logisticians. Major systems historically have been planned, designed, developed, and delivered to their customers with very little consideration given to logistics support. Today's systems cannot afford to shortchange logistics. To appreciate how acquisition logistics incorporates support considerations, one must understand the entire acquisition process, from the beginning to the end of a system's life cycle.

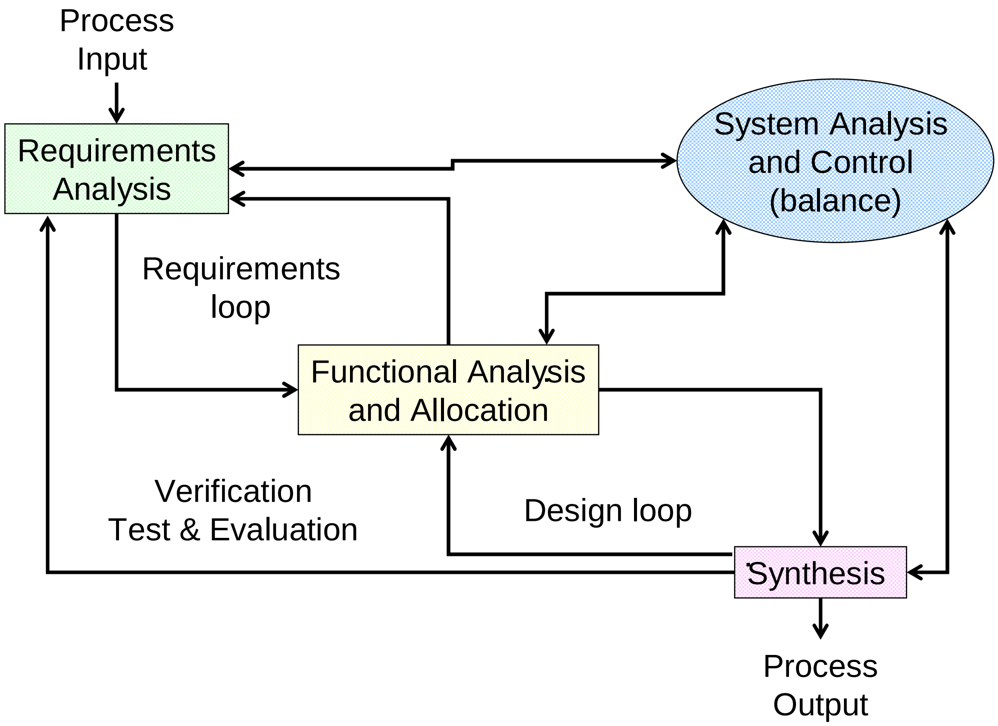
Logistics Supportability and Performance

Department of Defense (DOD) policy states that performance encompasses both the operational and the support characteristics of a system that allow it to perform its assigned mission effectively and efficiently over time. Supportability is a subset of performance and must be considered part of the performance criteria. The mechanism used to ensure that a holistic system design is achieved is called the systems engineering process. This process is applied to many functional areas by both the Government and contractors. Logistics considerations are just one part of the process. The systems engineering process used by DOD is depicted in the chart at right.

A system is more than just an end item or a single piece of equipment. It includes operators and maintainers, spare parts, support equipment, facilities, and training. In addition, systems designers are expected to address the system's compatibility with the rest of the support infrastructure. Logistics support begins with early planning for the system and continues throughout its useful life. Reliability, maintainability, and availability parameters are key leverage points in determining the depth and range of logistics support. The process is the same for all items, regardless of whether they are minor or major systems.

The process should emphasize the need to establish a logistics support management team early in the life cycle of a system. Acquisition logisticians work hand in hand with other engineering personnel to ensure that support is considered during the design process. The acquisition logistician in the program manager's office acts as the central point of contact for the program manager to assist each area in resolving problems affecting support of the emerging system. The logistics management integrated product team helps the acquisition logistician establish effective support for the system. Generally, the Government and the developing contractor co-chair the logistics management integrated product team.

Systems Engineering Process



Before the adoption of DOD 5000.2-R, Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs, in 1996, the acquisition logistician was called an integrated logistics support manager in all of the services. The Army still uses this term. The equivalent Air Force and Navy terms are assistant program manager of logistics and deputy program manager for logistics, respectively. Regardless of the title, the acquisition logistician is responsible for—

- Influencing the system's design.
- Preparing logistics support documents.
- Coordinating the system support package.
- Coordinating the materiel fielding agreements.

Available information will be limited at the early stage of the process; however, this should not stop the logistician from using historical data gathered from previously fielded comparable systems. Typically, historical data come from service repositories that capture supply and maintenance information on existing systems. (For the Army, the systems are the Standard Army Maintenance System, Standard Army Retail Supply System, and Unit Level Logistics System; the repositories are the Work Order Logistics File, Central Demand Database, and The Army Maintenance Management System Database.) Any data identifying how, when, and where the system will be used and maintained will establish a framework around which supportability factors can be formulated.

Since logistics is essentially a management of parts, keeping the cost of parts to a minimum is an essential task. Every part, no matter how small, has significant overhead costs. These costs are generated by such activities as ordering, receiving, stocking, delivering, reworking, and reordering the parts and supplying spares and technical manuals. To determine the total cost of a part, one must multiply these activities by the number of times they will be performed or acquired over the entire life of the system. The magnitude of the challenge can be seen when one understands that the C-17 transport has 9 million parts, the F/A-18 has 750,000 parts, and the AH-64 Apache helicopter has 30,000 parts.

Reliability, Maintainability, and Availability

The key to successful logistics support is detailed planning before the acquisition program starts. A supportability strategy, although not mandated, should be established early in the life cycle of a system. The Government must make a deliberate decision about the levels of support needed to sustain the system. The contractor will respond to the Government's vision of support by submitting a support plan. One of the key ingredients in developing the range and depth of support resources is forecasting the reliability of the system's design.

Reliability is the probability that an item can perform its intended function for a specified interval of time under stated conditions. Reliability also is the ability of an item or piece of equipment to operate consistently. Reliability describes in quantitative terms how free of failure the system is likely to be during a period of operation. An example of this is the frequency of problems experienced by the Navy's F-14s and A-6s.

Reliability can be defined as mean time between failure (MTBF). The ability to express reliability numerically is crucial because it identifies in concrete terms not only the user's needs but also contractual specifications, test guidelines, and performance assessments. This definition stresses four factors: probability, satisfactory performance, time, and specified conditions.

Probability is expressed as a percentile specifying the number of times that one can expect an event to occur in a total number of trials. For instance, a probability of failure-free performance of .75 for an item performing for 80 hours indicates that, 75 times out of 100, we can expect that item to function properly for 80 hours. Reliability depends heavily on concepts derived from probability theory.

Satisfactory performance uses specific criteria in qualitative or quantitative terms to define what the system ultimately must accomplish; these criteria usually are found in the Operational Requirements Document.

Time represents a measure against which system performance can be analyzed. Time is not measured strictly in terms of seconds, minutes, or hours. It is preferable to use an interval based on particular mission profiles (number of missiles fired, number of miles traveled, number of hours spent communicating, or length of mission).

Specified conditions constitute the scenarios in which the system will operate. These conditions might include temperature; humidity; weather; terrain; roads; desert, jungle, or arctic environments; mountains or rivers; operating tempo; nuclear, biological, and chemical conditions; mental ability of users; and hours of operation.

Maintainability measures an item's ability to be retained in or restored to a specified condition, when maintenance is performed by personnel having specified skill levels and using prescribed procedures and resources at each prescribed level of maintenance. Maintainability refers to the ease, accuracy, and economy of performing a maintenance action.

Maintainability is an inherent design characteristic of a system. The goal of maintainability is to design and develop a system that can be maintained in the least time, at the least cost, and with a minimum expenditure of support resources (such as manpower, spare parts, tools, and test, measurement, and diagnostic equipment [TMDE]). Maintainability refers to the ability of an item of equipment to be maintained, while maintenance refers to a series of actions that retain or restore an item to an operational state (such as inspecting, servicing, repairing, or overhauling). Maintainability design features might include redundancy, interchangeability of common modules, use of throw-away replaceable modules, and accessibility of parts. Thus, maintainability is a design parameter, while maintenance is a result of that design.

One typical measure of maintainability is mean time to repair (MTTR). This is the total elapsed time (typically expressed in clock hours) for performing corrective maintenance, divided by the total number of maintenance actions during a given period of time. In other words, MTTR shows how long it takes to fix and how difficult it is to repair or service a system.

Reliability and maintainability are two major system characteristics that combine to form the most commonly used measure of effectiveness—availability.

Availability is a measure of the degree to which an item is in an operable and committable state at the start of a mission that can be called for at a random time. The combination of reliability (MTBF) and maintainability (MTTR) is used to predict the amount of time a system will be available for use after it is fielded; in other words, how ready is a system to perform when needed?

Availability predictions are used when making tradeoffs among different system design concepts. Tradeoffs can be made to gain higher availability. A very expensive system can be designed with the intent that it will never break. A very cheap system can be designed with the intent that it will be thrown away when it breaks or is expended; it thus will be purchased in large quantities.

The results of reliability and maintainability studies are needed to form any measure of availability. Nevertheless, early in the conceptual phase of a system's life cycle, acquisition logisticians can, and often do, draw on information for existing systems to make assumptions about the availability of the new system before actual measures of that system's reliability and maintainability are produced.

As a characteristic of design, supportability of a system is affected directly by the decisions made during the design process of the system's hardware, software, and support infrastructure. For example, part of the manufacturing plan defines 25 engineering characteristics for each part that will be used in a system, such as dimensions, surface finishes, hardness, and material composition. This can equate to millions of specific engineering characteristics in large systems.

Acquisition Logistics Support Elements

The acquisition logistician must integrate diverse support elements to ensure effective support of a system. Each element must be orchestrated by a single entity to ensure that the resources needed to sustain operations are available when needed. The elements determine the life-cycle costs and the degree of operational readiness of the system after it is fielded. Although each of these elements may be developed or managed by different individuals or activities, the focal point is the logistician. If properly applied and monitored through the design and production phases of the acquisition process, the 10 elements described below will optimize the supportability of the system over its entire life.

Design interface is the relationship of logistics-related design parameters to readiness and support resource requirements. These logistics-related design goals are expressed in operational terms rather than as inherent values and specifically relate to system readiness objectives and support costs of the system. Design goals include—

- Improved ease of maintenance and repair and operational availability and reduced MTTR and MTBF.
- Minimized requirements for total number of parts and repair tools.
- Standardization of parts and use of multifunctional parts and multi-use parts.
- Use of modular designs, standard components, and embedded work platforms.
- Use of known materials and known manufacturing processes.
- Incorporation of human factors engineering (such as skill requirements, safety, and reduced hazardous materials).
- Accessibility, visibility, simplicity, and testability (such as built-in test equipment and TMDE).
- Use of labeling, identification, color coding, and quick connect and disconnect fasteners.
- Use of DOD standard data and digitized technical data.

- Use of open systems architecture for all designs.

Maintenance planning is the process of establishing maintenance concepts and requirements for the lifetime of the system. Essentially, this is selecting the appropriate level of maintenance: organizational, intermediate, depot, total contractor logistics support, or a combination of these.

Manpower and personnel is the element that identifies and acquires military and civilian personnel who have the skills needed to operate and support the system over its lifetime at both peacetime and wartime rates. Once the levels of maintenance are established, manning documents can be developed or changed for the system. Personnel can train at the contractor's facility to help the service schools develop the curriculum and program of instruction for the system. User aptitudes and individual capabilities are considered in relation to the system design.

Supply support includes all management actions, procedures, and techniques used to determine requirements for acquiring, cataloging, receiving, storing, transferring, issuing, and disposing of secondary items. Parts must be on hand to fix broken equipment. This includes provisioning for both initial support and replenishment supply support and for support and test equipment.

Support equipment includes all equipment (mobile or fixed) required to support the operation and maintenance of the system.

Technical data includes technical information on the system in a digitized medium, including engineering drawings, specifications, maintenance allocation charts, and repair parts and special tools lists. Excluded are financial data or other information related to contract administration.

Training and training support covers the processes, procedures, techniques, training devices, and equipment used to train civilian and military personnel to operate and support the system.

Computer resources support includes the facilities, hardware, system software, software development and support tools, documentation, and people needed to operate and support embedded computer systems.

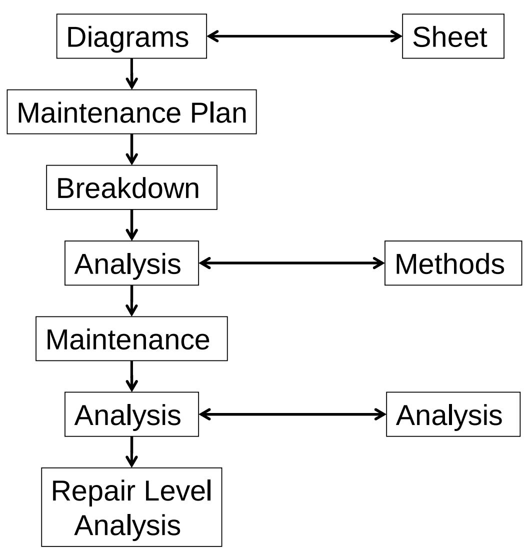
Facilities are the permanent, semipermanent, and temporary real property assets required to support the system.

Packaging, handling, storage, and transportation includes the resources, processes, procedures, design considerations, and methods used to ensure that all system, equipment, and support items are preserved, packaged, handled, and transported properly. This element covers environmental considerations, equipment preservation for short- and long-term storage, and transportability.

Supportability Strategy and Analysis

The acquisition logistician is responsible for preparing a supportability strategy that describes the support envisioned for the system. The supportability strategy provides the plan for operational support and the details of how the supportability program fits into the overall acquisition program. The supportability strategy serves as a source document for consolidating and summarizing the logistics support information needed to make sound decisions during the system's development and production.

Integral to the design process is supportability analysis (SA). SA is a set of activities conducted as a part of the systems engineering process to assist in complying with support objectives. (See chart at right.) The SA is accomplished in a rational, analytical manner and is not based on rules of thumb or best guesses. Reliability and maintainability studies, fuel and ammunition consumption, operator training, and transportation requirements will determine the logistics support resources needed by the system. SA is the principal tool for bringing supportability goals into reality. Although the current guidance set forth in DOD 5000.2-R does not stipulate specific procedures or guides for conducting any type of analysis, it seems logical to assume that any assessment by either the Government or a contractor should not be done in a haphazard fashion. The standard for this process is Military Handbook 502, Acquisition Logistics.



An abridged depiction of the supportability analysis process.

SA ensures that all elements of support are planned, acquired, tested, and deployed. Design changes should occur before the design is final in order to minimize problems before the system is put into operation. Typically, this takes place during the critical design review. The level and type of SA will vary from phase to phase; the current handbook on logistics indicates that there is an explicit need for SA throughout a system's life cycle. Verification of the systems engineering process provides the logistician with feedback over the entire acquisition process. The system verification review helps ensure that logistics data are valid and that the logistics program is reaching its objective. The chart above is an abridged depiction of the overall SA. This process, which usually is performed by the contractor, is very analytical, time consuming, and expensive. However, the result is generally worth any resources expended.

Decisions Influencing Life-Cycle Costs

Life-cycle costs are a critical element in the decisions made when acquiring systems. Life-cycle costs include the costs of developing, acquiring, and maintaining a system over its lifetime. Since systems often are projected to be in service for more than 50 years, life-cycle costs can be very substantial. Most life-cycle costs occur after the system is delivered.

Support costs generally make up over 60 percent of the total cost of a system over its lifetime. Support costs include maintenance personnel, fuel, repair parts, technical orders, facilities, and engineering changes. During the conceptual stage, participants in the integrated product team work primarily with paper studies, so design changes are relatively cheap and easily made. The engineers should not concern themselves solely with such characteristics such as performance, weight, or size. The logistician should try to establish a dialogue among the user, designer, manufacturer, tester, and all members of the integrated product team to bring support issues to bear on design.

As the design process moves from requirements analysis to functional analysis, logistics requirements will be refined. During functional analysis, information on what the proposed system will accomplish in a typical wartime mission will be examined along with system functions. Having all the functions identified at a specific level permits the logistician to define support needs. The logistics engineer will perform "what if" drills to determine the support resources needed for a given design. By exploring these and many other alternatives, the logistician can fully develop the best support for the eventual design.

Every operational and maintenance task should be evaluated and performed on the system. The major goal of this exercise is to pinpoint the need for facilities, spare parts, tools, support equipment, special training, and other support. The analysis should highlight mission-critical changes that exceed either cost or schedule objectives or that might warrant possible changes in the system's design.

Once the system's design has matured sufficiently and logistics support concepts have been formulated, the next step is to apply the results of the SA process to pinpoint the detailed logistics support resources that will be needed when the system is deployed. The emphasis of various tests will be on identifying and correcting deficiencies before the system is produced. Even commercial items must be evaluated to determine if they are suitable for military use.

Before the system's hardware and software are operationally tested, the current logistics support infrastructure must be assessed in a logistics demonstration. If the demonstration is conducted in a realistic combat scenario using current facilities, tools, personnel, and other support infrastructure, logistics weaknesses can be pinpointed. A thorough analysis of supply support requirements will dictate planning for the availability of parts once the production run is completed. When inadequate sources for spares are uncovered, alternative solutions should be analyzed and a preferred solution recommended.

The bottom line is to correct any known or potential post-production support problems before the system begins full-rate production. After production and into deployment, the emphasis shifts to verifying supportability and making improvements. The logistician will conduct an early fielding analysis to address the system's resource needs when it is in its projected combat environment. Failure to address potential problems adequately may degrade the new system's capability and lessen the readiness of gaining units for combat.

Deployment

The deployment plans for the Army, Air Force, and Navy are called the Materiel Fielding Plan, Site Activation Plan, and Phased Support Plan, respectively. The Navy also has another deployment plan, the User Logistics Support Summary, the primary purpose of which is support certification and user acceptance. The service-specific names for personnel conducting deployment are New Equipment Training Team for the Army, Bed-down Team for the Air Force, and Fleet Intro Team for the Navy. Deployment poses the greatest challenge to logisticians because failing to address logistics support thoroughly in the early stages of system development or to meet support milestones can translate into delays or, more importantly, a system that does not meet a unit's readiness goals. Even with the best analysis, potential support problems can surface later in the system's life cycle: uncertain system life spans, long lead times, uneconomical order quantities, budget problems, increased parts usage, inadequate technical data packages, deleted or no substitutes, obsolete design, lower reliability, inadequate sources of supply, or closing factories.

As DOD continues to change policies on logistics, our aging systems will present more challenges for acquisition logisticians. A continued focus on supportability in acquiring systems will ensure that logistics requirements will not hinder mission accomplishment.

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